

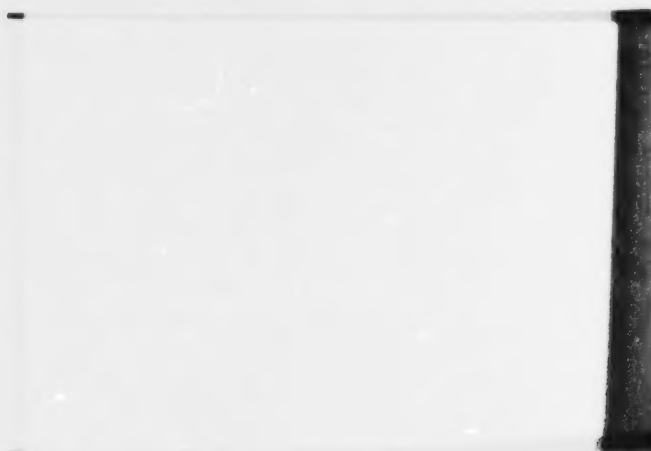


CMHC

Canada Mortgage
and Housing Corporation

SCHL

Société canadienne
d'hypothèques et de logement



EVALUATION OF THE EMR-SEE HOUSING CONCEPT
USING THE CMHC-2 PROGRAM

Prepared for
The Technical Research Division
Policy Development and Research Sector
of
Canada Mortgage and Housing Corporation
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April 1982
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EXECUTIVE SUMMARY

The Computer Model for Heating Cost-Effectively (CMHC-2), developed by Canada Mortgage and Housing Corporation, has been used to evaluate the proposed energy performance criteria of the EMR-SEE housing program, and compare it to that noted in the proposed CEA "Super Double E" Energy Efficient Home Award Program. Six house designs, in four locations, were analyzed. The space heating energy requirements, and the capital costs to improve the heating energy performance, to the CEA and SEE programs energy budget levels, were calculated. This evaluation was undertaken to assist in defining policy for the EMR-SEE housing program.

It was found that, for all cases, the CEA requirements were more stringent than the SEE requirements. Often it was found that there were insufficient steps available in the thermal improvement data base to meet the CEA budget, without also improving the air tightness of the house.

For the four cities studied, the range of costs incurred in improving the houses, from the 1975 standard insulation level to the SEE and CEA performance levels, are:

	<u>SEE</u>	<u>CEA</u>
Vancouver	\$3,000- 7,000	\$ 5,000-15,000
Saskatoon	\$6,000-14,000	\$10,000-16,000
Toronto	\$4,000-14,000	\$ 7,500-14,000
Fredericton	\$5,000-14,000	\$ 8,000-15,500

For the four sites studied, the range of space heating requirements for the houses modelled to the 1975 Standard insulation levels, and, SEE and CEA performance levels, are:

	<u>1975</u>	<u>SEE</u>	<u>CEA</u>
Vancouver	47-113 GJ	15-37 GJ	8-30 GJ
Saskatoon	65-160 GJ	20-70 GJ	20-70 GJ
Toronto	45-120 GJ	15-40 GJ	10-40 GJ
Fredericton	50-130 GJ	20-50 GJ	10-50 GJ

The last items of improvement for the houses had simple payback periods of fifty years or more.

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1.0 INTRODUCTION

EMR has proposed to support the construction of Super Energy Efficient (SEE) houses across Canada. The purpose of the SEE program is to foster energy related innovation in the housing industry, and provide substantial energy reductions.

The Canadian Electrical Association has proposed guidelines for new house construction, the purpose of which is to significantly reduce energy consumption of dwellings.

This report has been prepared to identify the implications of the SEE and CEA program criteria, using the CMHC-2 (Computer Model for Heating Cost-Effectively) program as a tool.

The object of this report is to identify the improvements, and associated costs, necessary to reduce the space heating energy consumption, of typical house designs, to the SEE and CEA levels, as determined by the CMHC-2 program.

2.0 METHODOLOGY

The CMHC-2 computer program was utilized in this study, to find the optimum thermal characteristics of the houses.

In performing the computer simulations, four representative cities were selected as test sites, viz: Vancouver, Saskatoon, Toronto and Fredericton. Appendix A contains climatic data for these cities. For each representative city, three styles of typical houses were modelled, these being, bungalow, split level, and two storey. For each style of dwelling, two nominal floor areas were studied; 90 m² and 150 m². Therefore, for each city, there were essentially six different houses studied. The architectural features, and dimensions of the houses, are presented in Appendix B.

As a special case, a large bungalow (150 m²) was modelled as a slab on grade, with Vancouver as the test site.

The minimum ventilation requirements were 0.5 acph. The mechanical systems features of the houses are presented in Appendix C.

Each housing model was simulated using three different thermal performance levels as follows:

- 1) 1975 STANDARDS, for non-electrically heated houses, as outlined by the NRC "Code".

- 2) Canadian Electrical Association (CEA) - Super Double - E House Standards.
- 3) SEE Housing Space Heating Performance Criteria.

The 1975 standards outline minimum insulation requirements. The CEA standards are a combination of minimum insulation levels, and a maximum allowable annual space heating energy requirement based on interior floor area. The SEE Housing Space Heating Criteria is a maximum allowable annual space heating energy requirement, also based on interior floor area. All of these insulation levels and space heating energy requirements are shown in Appendix D, E and F respectively.

The procedure for simulating the houses was as follows:

- 1) all of the houses were modelled using 1975 standards insulation levels.
- 2) using the optimizing program of CMHC-2, the houses were thermally upgraded (i.e., resistance values improved) from the 1975 standards insulation levels to meet the CEA space heating energy budget. A separate review was made to ensure that the CEA minimum insulation levels were also met.
- 3) using the optimizing program of CMHC-2, the houses were thermally upgraded from the 1975 standards insulation levels, to the SEE

Housing Space Heating energy budget. The requirement for a minimum wall thermal resistance value was not enforced or integrated into the results. The reason for this approach was deliberate, because CMHC questions its desirability. If it is imposed the improvement costs in mild climates (Vancouver and Toronto) will increase in some cases.

For each of the above cases, the thermal resistances, cost of improving the thermal resistances, and the annual space heating energy requirements were reported.

3.0 OVERVIEW OF CMHC-2

CMHC-2, the Computer Model for Heating Cost-Effectively, has been developed by Canada Mortgage and Housing Corporation to automatically identify the most cost-effective items for improving the energy performance of a house, and subsequently evaluate its viability. The version of the program used for this study was developed to calculate the space heating requirements of the house to a predetermined budget. The tolerance permitted between the space heating requirements and this budget was 5%. This space heating budget was achieved by improving the air tightness and thermal resistance of, the envelope of the house. Improvements to the space heating appliance or system efficiency were not used because of instructions from EMR that the S.H. program does not presently recognize furnace dynamics.

The CMHC-2 program presently uses mean monthly ambient temperatures for calculating the heating requirements of a house. The use of mean monthly temperatures for "low energy" houses can result in a significant bias dependent upon the climate and the ratio of heat gain to heat loss (breakeven temperature).

The magnitude of this discrepancy (or bias) for a variety of breakeven temperatures is summarized in Appendix table A-2. The breakeven temperature, above which it is considered that no heating is required, and below which it is considered that a "degree day" analogy can be used

to determine the heating requirements, can be computed as follows:

$$\text{Breakeven Temperature} = \text{Inside Temperature} - \frac{\text{Internal Heat Gain}}{\text{Heat Loss Factor}}$$

During this study, it was requested by EMR that an analysis of row housing be made, but this exercise was not performed because row houses, by their very nature, have lower breakeven temperatures, and consequently greater discrepancies, than do detached houses.

COST DATA BASE

The costs used for this study are intended to reflect the premiums that a buyer would pay for energy conservation features included in a house, built in 1982, in a tract housing development. They therefore include for both sub-contractors' and developers' profit and overheads as well as interim financing and sales expenses. No allowance has been made for increases in design fees, as it is assumed that stock plans are used.

The conservation options included represent those that have been commonly adopted by builders and the costs account for all entailed costs associated with the upgrading (e.g. modifications to door and window frames, modified trusses, delays in the work of other trades, etc.). It is recognized that there are cheaper options available for some of the upgrading (e.g. beadboard in lieu of extruded polystyrene), but, for this study, they were not used because they would involve some trade-off between performance and reliability.

Many small builders may be able to provide energy conservation options at lower costs than those included in the data base, particularly if they purchase materials and hire labour directly. They may also be willing to forego their profit and overheads on the conservation items, in order to enhance their merit as sales features.

Further details related to the cost data base used in this evaluation are presented in Appendix G.

4.0 FINDINGS

Appendix H summarizes the improvements, and related costs, made to various dwellings, when optimized to the CEA and SEE space heating energy levels.

Appendix I shows the space heating energy requirement of the houses modelled to the 1975 standards, the CEA standards, and the SEE Performance Criteria.

Appendix J summarizes the approximate heat loss factors of the houses modelled to the 1975 standards, CEA standards, and the SEE Performance Criteria.

Appendix K summarizes the improvements and related costs, the approximate heat loss factors, and the space heating requirements, of the bungalow slab on grade, when optimized from the 1975 Standards to the CEA and SEE Performance Criteria.

Space Heating Energy Requirements

The space heating energy requirements associated with the 1975 standards reveal that, generally, the split level and two storey houses, of equal nominal floor area and air change rates, have nearly equal space heating energy requirements. The bungalow houses require more energy than

either the split level or two storey houses, implying that the bungalow house is a less energy efficient shape of dwelling. The CEA and SEE space heating targets, calculated by the technique used, reveal that the split level house is a very energy efficient shape of dwelling.

Generally, the houses modelled with an air change rate of 0.5 acph were unable to meet the CEA and SEE space heating energy targets. The targets could not be achieved because the number of alternatives for reducing energy consumption available in the CMHC-2 'library' were exhausted. In contrast, all houses modelled with an air change rate of 0.2 acph reached the CEA and SEE space heating energy targets.

Thermal Improvements and Costs

The cost of improving the houses modelled with an air change rate of 0.5 acph was very high, generally in excess of \$10,000, and would have been considerably more had the energy targets been attained. In contrast, the 0.2 acph houses required the expenditure of significantly less money to reach the energy targets.

For any house, the cost of the improvements, and the savings in heating from those improvements, are least in Vancouver and greatest in Saskatoon.

The cost of the CEA improvements are greater than those of the SEE, and are due to the space heating energy target for the CEA being lower than the SEE. The difference in costs, when related to the savings in energy, reveal that the CEA levels are very costly to attain. The improvements made, to go from the SEE to the CEA standards, call for extremely long simple payback periods, sometimes over one hundred years on the "last" items of improvement. In all cases, the CEA minimum insulation levels were exceeded prior to meeting the energy budget.

The heat loss factors in Appendix J can be used, in conjunction with Table A-2, to determine the level of inaccuracy of the predicted space heating requirements produced by using monthly average temperatures instead of processed hourly data. The SEE houses in Vancouver, with nominal floor area of 90m^2 and low infiltration rates, have the lowest heat loss factors of about $125\text{ W/}^\circ\text{C}$. Table A-2 shows that houses, with this heat loss factor, could have actual space heating requirements $1\frac{1}{2}$ times as great as the predicted requirements. The lowest heat loss factors, for the SEE houses in Saskatoon, Toronto, and Fredericton, are 85, 105 and $95\text{ W/}^\circ\text{C}$ respectively. These could yield actual space heating 1.0, 1.2 and 1.1 times as great as the predicted requirements for Saskatoon, Toronto and Fredericton respectively.

5.0 CONCLUSION

- For the four sites studied, the range of costs incurred in improving the houses, from the 1975 standard insulation level to the SEE and CEA performance levels, are:

	<u>SEE</u>	<u>CEA</u>
Vancouver	\$3,000- 7,000	\$ 5,000-15,000
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- For the four sites studied, the range of space heating requirements for the houses modelled to the 1975 Standard insulation levels, and, SEE and CEA performance levels, are:

	<u>1975</u>	<u>SEE</u>	<u>CEA</u>
Vancouver	47-113 GJ	15-37 GJ	8-30 GJ
Saskatoon	65-160 GJ	20-70 GJ	20-70 GJ
Toronto	45-120 GJ	15-40 GJ	10-40 GJ
Fredericton	50-130 GJ	20-50 GJ	10-50 GJ

- The split level dwelling is the most energy efficient shape of dwelling, followed by the two storey and, lastly, the bungalow.
- The cost of improvements are generally greater for the slab on grade bungalow, than they are for the full basement bungalow, because of the way the energy budget is calculated.
- The CEA and SEE energy usage levels cannot be achieved at the "conventional" infiltration (air flow) rates of 0.5 ACPH.
- The use of mean monthly temperatures results in an error of 50% and 20% in the prediction of space heating requirements for the small, low infiltration rate SEE houses in Vancouver and Toronto respectively.
- Reservations have been noted in Appendix F regarding the technique used to calculate the energy budgets for the houses. Houses with basements have a higher than appropriate energy budget.
- The requirement for a minimum wall thermal performance level did not appear necessary in, or appropriate for, this program.
- The last items of improvement for the houses had payback periods of fifty years or more.

APPENDIX A

APPENDIX A

CLIMATIC DATA FOR THE REPRESENTATIVE CITIES

There were four representative cities selected as test sites for this report, viz: Vancouver, Saskatoon, Toronto and Fredericton. Solar radiation data, and mean monthly temperature data were provided by the data base within the CMHC-2 program.

Table A-1 shows the degree days, and design temperature, for the four representative cities.

TABLE A-1

CLIMATIC DATA FOR THE REPRESENTED CITIES*

City	Degree Days below 18°C	Design Temperature January 2½% °C
Vancouver	3005	- 7°C
Toronto	4082	-18°C
Fredericton	4699	-24°C
Saskatoon	6077	-35°C

* From National Building Code

TABLE A-2

SUMMARY OF DISCREPANCY OBTAINED WHEN MONTHLY MEAN
TEMPERATURES ARE USED TO OBTAIN HEATING DEGREE DAYS

Breakeven Temp. °C	Corresponding House Heat Loss Factor Watt/°C	Saskatoon		Montreal ⁴		Toronto		Vancouver	
		DD ⁶	% DD ⁷	DD ⁶	% DD ⁷	DD ⁶	% DD ⁷	DD ⁶	% DD ⁷
18 ⁵	600	6030	101.2	4590	94.8	4170	95.0	3070	96.8
15	300	5150	98.1	3800	93.2	3370	93.9	2185	92.7
10	164	3850	97.3	2620	92.1	2200	91.7	970	89.2
5	113	2780	96.6	1680	90.2	1290	88.9	270	50.0
0	86	1910	98.4	980	84.6	620	79.7		
-5	69	1230	70.8	510	60.4				

NOTES: 1 - Inside temperature = 21°C;

2 - Internal heat gain = 1800 watt;

3 - Airport weather data is used;

4 - Fredericton and Montreal have similar climates, and for this report the use of Montreal degree days, in place of Fredericton degree days, is used because analysis of the Fredericton long term hourly weather (climate) has not yet been completed;

5 - Published degree days (DD) to the base 18°C are 6077, 4472, 4082 and 3005 respectively;

6 - Degree-Days obtained by analysis of long term hourly weather;

7 - DD monthly analysis + DD hourly analysis

APPENDIX B



APPENDIX B

ARCHITECTURAL FEATURES OF THE SIX HOUSES

Three styles of typical houses were modelled, viz: Bungalow, Split-Level, and Two Storey. These styles represent typical detached housing types in Canada.

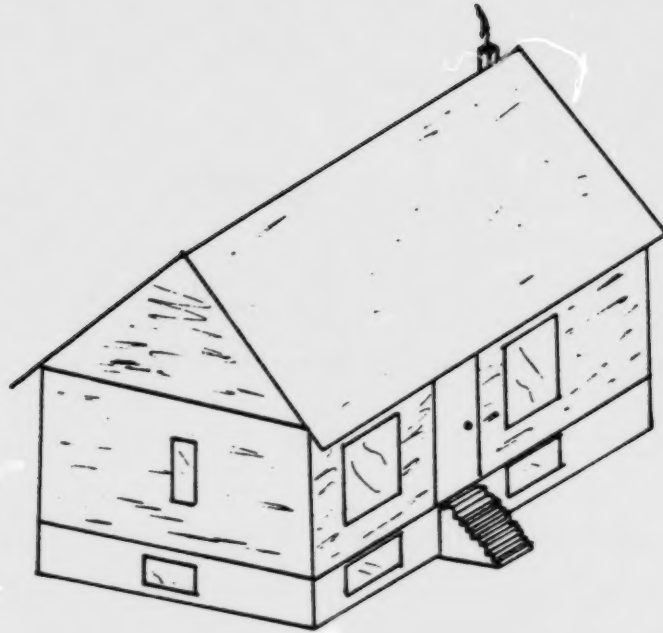
For each style of dwelling, two nominal floor areas were studied; 90 m² and 150 m². Therefore, six different houses were analyzed. The Slab on Grade house, modelled at Vancouver, had a nominal floor area of 150m². Figures B-1 and B-2 show the isometrics and sections of the houses, respectively.

The total surface area of windows of the dwelling is equal to 10% of the nominal floor area. Of this total window area, 50% is on the south face of the dwelling, with the remainder evenly distributed on the other three faces.

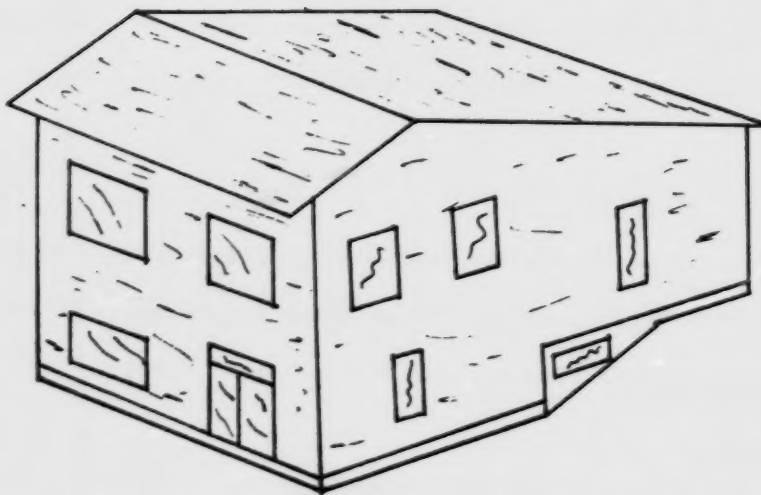
Dimensioning of Dwellings

The nominal floor area of the dwelling was calculated using the projected floor area of the dwelling, using the exterior dimensions. It does not include areas associated with the basement or crawl spaces.

The interior volume of the dwelling is obtained by using the interior dimensions of the exterior walls. The areas of the exterior walls and ceilings are based upon their exterior dimensions for the initial case. It does not change for those cases where the wall thickness was increased to accomodate the additional insulation levels.



BUNGALOW

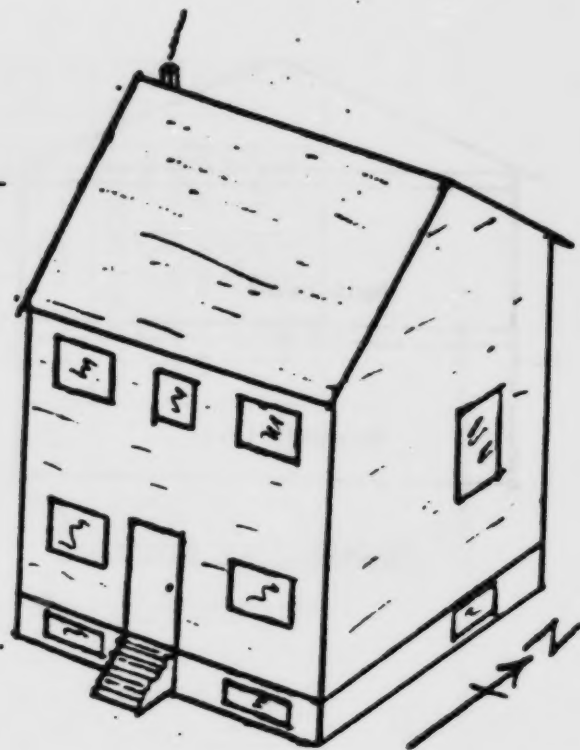


SPLIT LEVEL

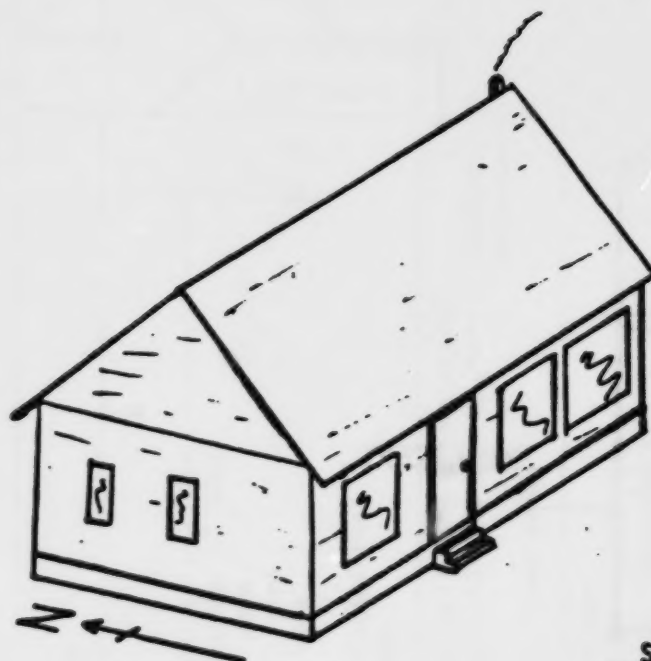
FIGURE BI

PERSPECTIVES OF THE HOUSES

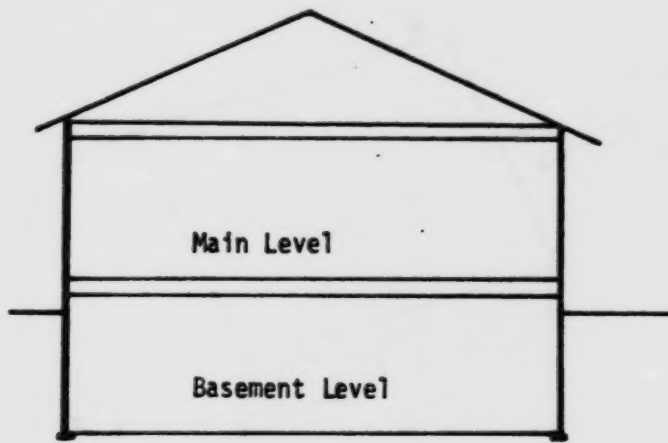
FIGURE BI (cont'd)
PERSPECTIVES OF THE HOUSES



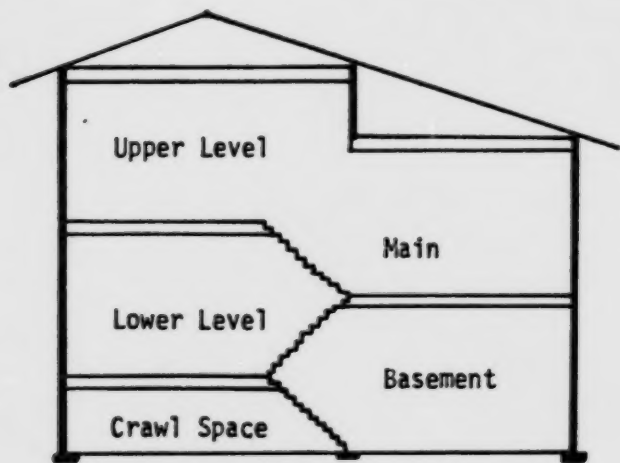
TWO STOREY



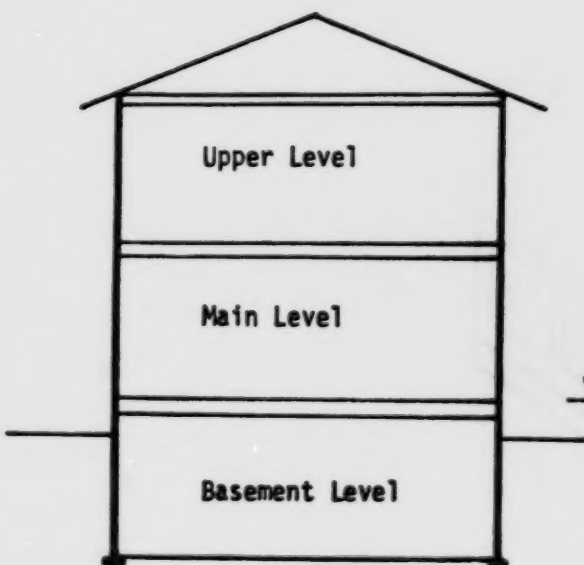
SLAB ON GRADE
BUNGALOW



Bungalow (Full Basement)



Split Level



Two Storey

FIGURE B2

SECTIONS OF THE HOUSES

TABLE B-1

Physical Dimensions of the Houses*

Variable	Units	Bungalow		Bungalow Slab on Grade	Split Level		Two Storey	
		Small	Large		Small	Large	Small	Large
House Size								
Circumference of house	m	38.2	49.2	49.2	31.2	39.2	27.0	34.8
Ceiling area	m ²	90.0	150.0	150.0	59.4	94.4	45.0	75.0
Net Wall area	m ²	104.7	132.1	116.2	140.4	172.1	144.6	183.8
Window area	m ²							
South	m ²	4.5	7.5	7.5	4.5	7.5	4.5	7.5
North+East+West	m ²	4.5	7.5	7.5	4.5	7.5	4.5	7.5
Door area	m ²	3.6	3.6	3.6	3.6	3.6	3.6	3.6
Basement wall area (above grade)	m ²	16.6	21.7	0.0	11.3	14.6	11.5	15.1
Basement wall area (below grade)	m ²	11.6	15.0	0.0	9.4	11.8	8.2	10.6
Basement floor area	m ²	64.1	82.5	0.0	27.9	35.6	45.3	58.4
	m ²	90.0	150.0	150.0***	59.4	94.4	45.0	75.0
House volume	m ³	408.0	700.0	329.0	301.9	494.0	294.0	512.0
Controlled Ventilation	L/S	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Main Floor Temperature	°C	21.0	21.0	21.0	21.0	21.0	21.0	21.0
Basement Temperature	°C	18.0	18.0	-	18.0	18.0	18.0	18.0
Appliance Consumption	kWh/day	15.4	15.4	15.4	15.4	15.4	15.4	15.4
Hot water consumption	kWh/day	12.0	12.0	12.0	12.0	12.0	12.0	12.0
Weighted average # of people ****	-	1.5	1.5	1.5	1.5	1.5	1.5	1.5

* All dimensions are exterior dimensions.

** Insulation extends 300 mm below grade for the 1975 Standards.

*** Main Floor on Grade.

**** Continuous occupancy, equivalent to actual integrated occupancy by a representative family.

APPENDIX C



APPENDIX C

MECHANICAL SYSTEMS FEATURES OF THE SIX HOUSES

1) Equipment, Appliance and Domestic Hot Water Energy Requirements

EMR suggested that we restrict appliance, lighting, etc., and DHW energy usage to 10,000 kwh per year. From field tests and analysis performed by the Prairie Regional station of the National Research Council on thirteen low energy houses*, it was found that the average equipment and DHW energy consumption was about 16,900 kwh per year, which is significantly higher than the EMR directive (see calculations below). In order to reduce energy consumption to the 10,000 kwh per year level, it appears necessary to install energy efficient appliances and hope that the occupants minimize the use of such appliances.

Results of National Research Council Tests

- average appliance and lights electrical consumption
= $41.0 \frac{\text{GJ}}{\text{year}} = 11,389 \frac{\text{kwh}}{\text{year}} = 31.2 \frac{\text{kwh}}{\text{day}}$
- average DHW consumption of natural gas
= $36.4 \frac{\text{GJ}}{\text{year}}$
- if gas efficiency = 55% then average energy required for DHW
= $20 \frac{\text{GJ}}{\text{year}} = 5555 \frac{\text{kwh}}{\text{year}} = 15.2 \frac{\text{kwh}}{\text{day}}$

Equivalent electrical consumption for appliances and DHW
= $11,389 + 5555 \frac{\text{kwh}}{\text{year}}$
= $16,944 \frac{\text{kwh}}{\text{year}}$

*From "Energy Consumption Measurements Energy Showcase Project"
3 November 1980 to 3 November 1981
R.S. Dumont Saskatoon

Breakdown of Electrical Consumption

In this work the distribution of electrical consumption is as follows:

	%	kWh/yr.	kWh/day
DHW	44	4,400	12.0
Appliances, Lights	56	5,600	15.4
Total electrical	100	10,000	27.4

11) Ventilation Requirements

Two representative air change rates were assigned to quantify the heating requirements of two quite different construction alternatives. A rate of 0.5 air changes per hour (ACPH) was assigned to the base or typical house to represent the infiltration/exfiltration exchange. A rate of 0.2 ACPH was assigned to a house with an exceptional air-vapour barrier and an air-to-air heat exchanger. One "profile" which would consume the same quantity of heat as 0.2 ACPH and provide the same ventilation rate as 0.5 ACPH is as follows:

0.05 acph for infiltration/exfiltration due to door and window openings and 0.45 acph through an air-to-air heat exchanger with 67% seasonal efficiency (or requires 33% of the heat input otherwise required). Thus the value of $(0.05 + 0.33 \times 0.45)$ acph or 0.2 acph is a measure of the heat required by the ventilation air.

Table C-1 presents, for each house modelled, the air flow rates associated with the two ventilation rates described above. The table also presents an estimate of the installed cost of an air-to-air heat exchanger, the installed cost premium of an air-vapour barrier, compared to a standard vapour barrier, and the sum of these two costs presented as a total airtightness cost.

iii) Temperatures within the Dwellings

The temperature within the above grade portions of the house was modelled at 21°C. The comparable temperature for below grade areas was 18°C.

iv) Persons within the Dwellings

It is assumed that over a 24 hour period, there will be an average of 1.5 persons occupying each dwelling.

v) Thermal Mass of the Dwellings

The buildings modelled are considered to be of conventional construction. This conventional construction means that the houses do not have unusual thermal mass for storage of passive solar heat gain.

TABLE C-1

House	Bungalow			Split Level		Two Storey	
	Slab on Grade	Small	Large	Small	Large	Small	Large
House Volume m ³	329	408	700	358	624	294	512
Assigned Acph* Corresponding Heat Exchanger Flowrate** L/S (cfm) Assigned Leakage Acph	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	41.1 (87)	51.0(108)	87.5 (185)	44.8(95)	78.0(165)	36.8 (78)	64.0(136)
	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Assigned Acph* Corresponding Flowrate** L/S (cfm)	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	45.7 (97)	56.7(120)	97.2 (206)	49.7(105)	86.7(184)	40.8 (87)	71.1(151)
Cost of air to air heat exchanger \$	1,000	950	1,020	980	1,050	980	1,050
Cost of reducing infiltration \$	820	880	1,060	940	1,050	870	1,020
Total air- tightness cost \$	1,820	1,830	2,080	1,920	2,100	1,850	2,070

* Assigned Acph = Heat Exchanger Flowrate/House Volume + Assigned Leakage.

**Flowrate = air changes per hour x volume of house.

APPENDIX D



APPENDIX D

1975 THERMAL PERFORMANCE STANDARDS

The 1975 Standards insulation levels were presented in the National Building code for 1975, by the National Research Council of Canada. The Standards specify minimum insulation levels, relative to the degree days of the location, and the January design temperature. The Standards are shown in Table D-1 and D-2.

TABLE D-1

1975 STANDARDS MINIMUM INSULATION LEVELS*

	Minimum Thermal Resistance ($\frac{m^2 \cdot ^\circ C}{W}$)				
Building Assembly	Maximum No. of Celcius Degree Days**				
	up to 3333	4444	5556	6667	7778 and over
Walls	1.73	2.08	2.38	2.47	2.47
Exposed Floors and Ceilings	1.73	2.08	2.38	2.64	2.89
Basement *** Walls	1.48	1.48	1.48	1.48	1.48
Basement Floor	0.0	0.0	0.0	0.0	0.0
Doors	0.4	0.4	0.4	0.4	0.4
Windows	0.15 (Design temperature $\geq 15^\circ C$)		0.35 (Design temperature $\leq 16^\circ C$)		

* See Residential Standards, 1975, NRC. Applicable for heating sources other than electrical.

** Degree days are to the base of $18^\circ C$.

*** Insulation extends 300 mm below grade.

NOTE: Where the degree days for a particular area are different from those listed, interpolation between the listed values is permitted to obtain the required "R" value.

TABLE D-2

Baseline House Thermal Configuration

HOUSE TYPE		LOCATION	75 STANDARDS THERMAL CHARACTERISTICS*						
			Walls	Ceiling	Window	Basement Walls		Basement Floor	Door
						Below Grade **	Above Grade		
Bungalow		Vancouver	1.63	1.63	0.15	1.48***	1.48	0.0	0.4
Split Level		Vancouver	1.63	1.63	0.15	1.48	1.48	0.0	0.4
2 Storey		Vancouver	1.63	1.63	0.15	1.48	1.48	0.0	0.4
Bungalow		Saskatoon	2.42	2.50	0.35	1.48	1.48	0.0	0.4
Split Level		Saskatoon	2.42	2.50	0.35	1.48	1.48	0.0	0.4
2 Storey		Saskatoon	2.42	2.50	0.35	1.48	1.48	0.0	0.4
Bungalow		Toronto	1.97***	1.97	0.35	1.48	1.48	0.0	0.4
Split Level		Toronto	1.97	1.97	0.35	1.48	1.48	0.0	0.4
2 Storey		Toronto	1.97	1.97	0.35	1.48	1.48	0.0	0.4
Bungalow		Fredericton	2.15	2.15	0.35	1.48	1.48	0.0	0.4
Split Level		Fredericton	2.15	2.15	0.35	1.48	1.48	0.0	0.4
2 Storey		Fredericton	2.15	2.15	0.35	1.48	1.48	0.0	0.4

* Thermal resistance ($m^2 \cdot ^\circ C / Watt$)

** Insulation extends 300 mm below grade.

*** 1975 Standards require 1.48, but, to properly utilize program costing, 1.5 was used.

**** 1975 Standards require 1.97, but, to properly utilize program costing, 2.0 was used.

APPENDIX E



APPENDIX E

Canadian Electrical Association Super Double-E House Standards

The CEA Standards identify a maximum permitted energy budget for a house, depending on the degree days of the location. This budget is to be met by meeting minimum insulation requirements, and proper air management levels. The basis for this budget is shown in Table E-1, and the budgets for the houses analyzed is noted in Table E-2. The minimum prescribed thermal resistances are noted in Table E-3 and E-4.

Further details of this standard are in the proposal for CEA "Super Double-E" energy efficient Home Award Program, by "Double E Home Technical Committee", Toronto, September 1981.

TABLE E-1

Celsius Degree Days ZONE (2)	Maximum Annual Energy Requirements as per Floor Space (kW.h/m ² year)		
	Lighting, Appliances & Water Heating	Space Heating	Total
1 - up to 3500 (3000 DD average)	55	+20	75
2 - 3501 to 5000 (4250 DD average)	55	+25	80
3 - 5001 to 6500 (5750 DD average)	55	+35	90
4 - 6501 to 8000 (7250 DD average)	55	+45	100
5 - 8001 and over (8750 DD average)	55	+55	110

NOTES:

1. Floor space includes basement, living and 50% of crawl space floor area, as measured by interior dimensions.
2. Where the number of degree days for a particular area is different from those listed, interpolation between values shown in the table may be made to obtain the maximum annual energy requirements.

TABLE E-2

CEA "DOUBLE E" SPECIFIED ANNUAL SPACE HEATING REQUIREMENTS OF THE HOUSES

VARIABLE	UNITS	BUNGALOW		BUNGALOW SLAB ON GRADE	SPLIT LEVEL		TWO STOREY	
		Small	Large		Small	Large	Small	Large
HOUSE SIZE								
DOUBLE E FLOOR AREA *	m ²	157.6	270.0	135.0	116.4	190.4	111.4	193.8
<u>Space Heating Requirements</u>								
Vancouver (20.2 kWh/m ²)	kWh GJ	3184 11.5	5454 19.6	2727 9.8	2351 8.5	3846 13.8	2250 8.1	3915 14.1
Saskatoon (37.2 kWh/m ²)	kWh GJ	5863 21.1	10044 36.2	- -	4330 15.6	7083 25.5	4144 14.9	7209 26.0
Toronto (24.5 kWh/m ²)	kWh GJ	3861 13.9	6615 23.8	- -	2852 10.3	4665 16.8	2729 9.8	4748 17.1
Fredericton (28.0 kWh/m ²)	kWh GJ	4413 15.9	7560 27.2	- -	3259 11.7	5331 19.2	3119 11.2	5426 19.5

* Double E floor area includes basement, living and 50% of crawl space floor area, as measured by interior dimensions.

TABLE E-3

CEA "DOUBLE E" MINIMUM INSULATION LEVELS*

Minimum Thermal Resistance ($\frac{m^2 \cdot ^\circ C}{W}$)					
BUILDING ASSEMBLY	WALLS	CEILINGS	BASEMENT WALLS	BASEMENT FLOOR	DOORS
(For all degree day zones)	3.5	7.0	2.1**	0.0	0.7
	Maximum No. of Celcius Degree Days***				
	Up to 5799		5800 and over		
WINDOWS	0.36	0.56			

* See "Technical Guidelines for New Homes", Canadian Electrical Association, 1981.

** Insulation to a minimum of 0.61 m below grade.

*** Degree days based on 18°C.

TABLE E-4

MINIMUM CEA "DOUBLE E" INSULATION REQUIREMENTS

HOUSE TYPE	LOCATION	CEA "DOUBLE E" THERMAL CHARACTERISTICS*						
		Walls	Ceiling	Window	Basement Walls		Basement Floor	Door
					Below Grade **	Above Grade		
Bungalow	Vancouver	3.5	7.0	0.36	2.1	2.1	0.0	0.7
Split Level	Vancouver	3.5	7.0	0.36	2.1	2.1	0.0	0.7
2 Storey	Vancouver	3.5	7.0	0.36	2.1	2.1	0.0	0.7
Bungalow	Saskatoon	3.5	7.0	0.56	2.1	2.1	0.0	0.7
Split Level	Saskatoon	3.5	7.0	0.56	2.1	2.1	0.0	0.7
2 Storey	Saskatoon	3.5	7.0	0.56	2.1	2.1	0.0	0.7
Bungalow	Toronto	3.5	7.0	0.36	2.1	2.1	0.0	0.7
Split Level	Toronto	3.5	7.0	0.36	2.1	2.1	0.0	0.7
2 Storey	Toronto	3.5	7.0	0.36	2.1	2.1	0.0	0.7
Bungalow	Fredericton	3.5	7.0	0.36	2.1	2.1	0.0	0.7
Split Level	Fredericton	3.5	7.0	0.36	2.1	2.1	0.0	0.7
2 Storey	Fredericton	3.5	7.0	0.36	2.1	2.1	0.0	0.7

* Thermal resistance ($m^2 \cdot ^\circ C / \text{Watt}$).

** Insulation to a minimum of 0.61 m below grade. Below this no insulation is required.

APPENDIX F



APPENDIX F

SEE Housing Space Heating Performance Criteria-EMR

The space heating energy budget used is essentially that proposed by R. Dumont in "A Few Notes on the 1000 Low Energy House Program", December 1981.

The energy target has a sliding scale for space heating energy consumption related to the severity of the climate.

The target is as follows - the maximum energy consumption for space heating should not exceed the following value:

$$E_{MAX} = 25 \frac{\text{kWh}}{\text{m}^2} + \frac{25 \text{ kWh/m}^2 \times \text{D.D.}}{6000 \text{ }^\circ\text{C-days}} \quad (\text{F-1})$$

where

E_{MAX} = Maximum Energy Consumption, per unit (floor) area, for Space Heating $\frac{(\text{kWh})}{(\text{m}^2)}$

D.D. = Annual Degree-days for the location ($^\circ\text{C-days}$)

From equation F-1, the allowable space heating energy consumption values are:

	$E_{MAX}(\text{kWh/m}^2)$
Vancouver	38
Toronto	42
Fredericton	46
Saskatoon	50

The SEE space heating budget in this analysis differs from the way Dumont of NRC and the TRD of CMHC would calculate the size of the house. Dumont proposes that the floor area of the house be based on the interior heated volume. The TRD of CMHC submits that living area (floor area) is more important than living volume, hence the recommended SEE energy budget would be based on an "equivalent" floor area.

The equivalent floor area would be calculated as follows:

equivalent floor area = measured floor area x utilization factor

where measured floor area uses interior dimensions. The utilization factor might be as follows:

IDENTIFICATION	UTILIZATION FACTOR
Living	100%
Basement	75%*
Crawl Space	(if it is used for storage) 50%
Heated Porch	50%
Unheated Porch and Garages	0%

* For this evaluation, EMR requested that a utilization of 100% be used for the basement floor area. By doing this the CEA and SEE results may be directly compared.

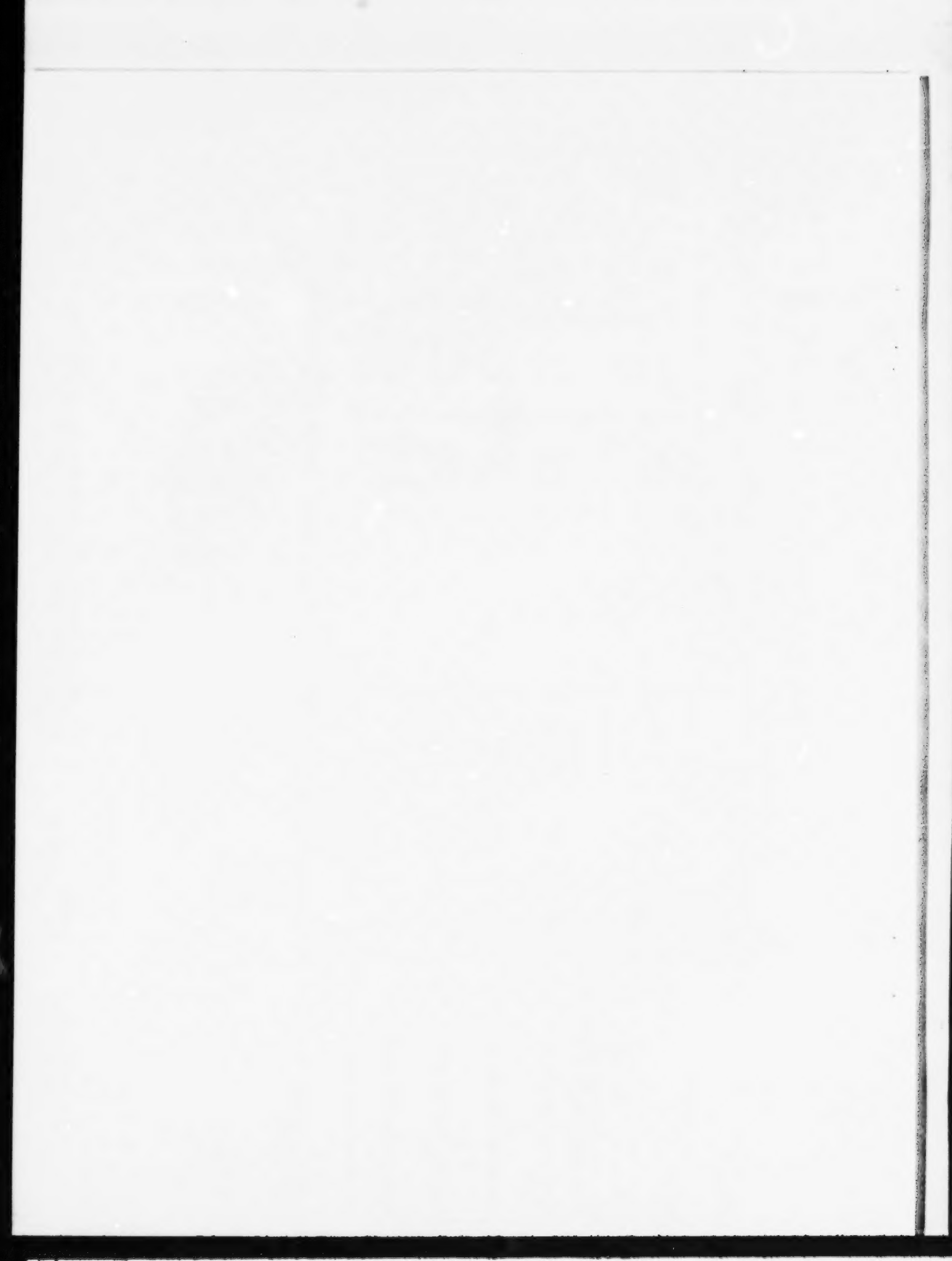
Based on the preceding, the equivalent floor area and space heating budget of the houses were calculated and are presented in Table F-1.

TABLE P-1

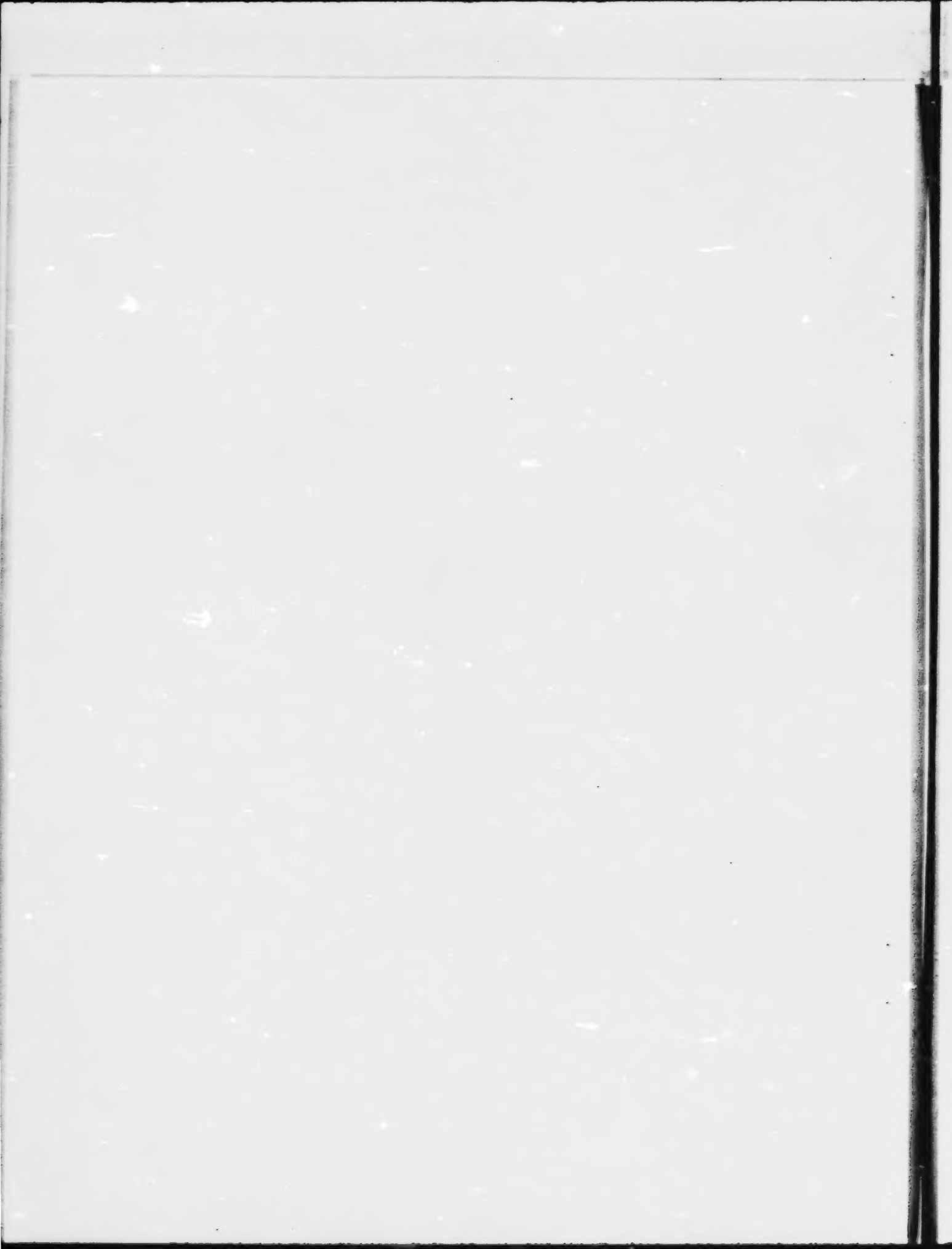
SEE SPACE HEATING ENERGY BUDGET

VARIABLE	UNITS	BUNGALOW		BUNGALOW SLAB ON GRADE	SPLIT LEVEL		TWO STOREY	
		Small	Large		Small	Large	Small	Large
HOUSE SIZE								
EQUIVALENT FLOOR AREA*	m ²	157.6	270.0	135.0	116.4	190.4	111.4	193.8
<u>Space Heating Requirements</u>								
Vancouver (38 kWh/m ²)	kWh GJ	5989 21.6	10260 36.9	5130 18.5	4423 15.9	7235 26.0	4233 15.2	7364 26.5
Saskatoon (50 kWh/m ²)	kWh GJ	7880 28.4	13500 48.6	- -	5820 21.0	9520 34.3	5570 20.1	9690 34.9
Toronto (42 kWh/m ²)	kWh GJ	6619 23.8	11340 40.8	- -	4889 17.6	7997 28.8	4679 16.8	8140 29.3
Fredericton (46 kWh/m ²)	kWh GJ	7250 26.1	12420 44.7	- -	5354 19.3	8758 31.5	5124 18.4	8915 32.1

* SEE Equivalent floor area includes basement, living and 50% of crawl space floor area, as measured by interior dimensions.



APPENDIX G



APPENDIX G

Cost Data Base

Table G-1 shows the cost data base (\$/m²), which was prepared for this project and used to develop the costs of improvements to the ceiling, interior walls, windows, exterior doors, basement walls, and basement slabs.

Table G-2 shows the ranking of these improvements when their cost effectiveness is evaluated.

In this study, the cost data base has been presented so as to allow the depth of the ceiling insulation to extend beyond the depth of the ceiling joist. In allowing this to occur, compression of the insulation results at the ceiling boundary, where the joists meet the roof rafters and sheathing. The compression of the insulation results in a performance penalty, which is not accounted for in this analysis.

Description of Cost Data

Ceiling

- | | |
|--------------|---|
| Base Ceiling | - Standard trusses 600 mm, 13 mm drywall. |
| Stream 1 | - Blown cellulose insulation, trusses 600 mm O.C., raised heel @ R8 (200 mm heel), gypsum board increased to 5/8" @ R8. |

Stream 2 - Same as above except fiberglass batt insulation.

Exterior Walls

Base Exterior Walls - 38 x 89 studs @ 600 mm O.C., 13 mm drywall, 10 mm polyethylene, sheathing paper, metal siding, fiberglass batts R1.41, asphalt impregnated fiberboard (Fibreboard).

Stream 1 - Base except R2.11 fiberglass batts and extruded polystyrene.

Stream 2 - As above except R2.46 fiberglass batts and extra estimated costs for extra cost of siding and doors and window frames (due to increased additional building area).

Stream 3 - 38 x 140 studs @ 600 mm O.C., etc. as above except R3.52 fiberglass batts and extra costs for increased building area.

Stream 4 - 38 x 140 studs @ 600 mm O.C., and 38 x 64 horizontal barrier @ 600 mm O.C. (i.e. retrofit ready wall), etc. as above except R1.41 fiberglass batts added, and extra cost due to increased building area.

Stream 5 - Double Wall - 38 x 140 studs and 38 x 64 studs each @
600 mm O.C. etc. as before except R3.52 and R2.11
fiberglass batts and extruded polystyrene.

Windows

Base Window - Single glazed.

Stream 1 Factory sealed only.

- double glazing (FS).

- triple glazing (FS).

Stream 2 Storms.

- Base and storm.

- double glazing (FS) and storm.

- triple glazing (FS) and storm.

Exterior Doors

Base Door - 50 mm wood slab.

Stream 1 - 45 mm urethane core door or same with storm door.

Basement Walls

Base Basement Walls - 200 mm poured concrete with existing dampproofing.

Stream 1 - Exterior Insulation - As base plus extruded polystyrene and parging on lath.

Stream 2 - Interior Insulation - As base plus 38 x 64 studs @ 600 mm O.C., polyethylene 10 mm, drywall 13 mm, fiberglass batts.

Basement Slabs

Base Basement Slab - 76 mm poured concrete slab.

Stream 1 - As base plus extruded polystyrene.

CEILINGS

1 2

1.40	0.0	0.0
1.60	0.24	1.08
1.80	0.48	0.0
2.00	0.72	1.72
2.20	0.96	0.0
2.40	1.20	2.15
2.50	1.44	0.0
2.60	1.68	0.0
3.00	1.92	3.37
3.20	2.17	0.0
3.40	2.40	3.61
3.50	2.54	3.94
3.60	2.68	4.27
4.00	3.12	4.00
4.20	3.35	4.93
4.40	3.58	5.20
4.50	3.61	5.59
4.60	4.04	5.92
5.00	4.27	5.22
5.20	4.50	5.55
5.40	4.73	5.88
5.50	4.96	7.21
5.60	5.19	7.54
5.80	5.42	7.87
6.20	5.65	3.20
6.40	5.88	6.53
6.50	6.11	3.86
6.60	6.34	7.19
7.00	6.57	7.52

TABLE G-1

COST DATA BASE

7.20	6.80	9.85
7.40	7.03	10.18
7.50	7.26	10.51
7.60	7.49	10.84
8.00	12.36	15.80
8.20	12.59	15.23
8.40	12.82	15.56
8.50	13.05	16.89
8.60	13.28	17.22
9.00	13.51	17.55
9.20	13.73	17.88
9.40	13.95	18.21
9.50	14.17	18.54
9.60	14.39	18.87
10.00	14.61	19.20
10.20	14.83	19.53
10.40	15.05	19.86
10.60	15.27	20.19

EXTERIOR WALLS

	1	2	3	4	5
2.00	0.0	0.0	0.0	0.0	0.0
2.30	0.03	0.0	0.0	0.0	0.0
2.70	1.15	0.0	0.0	0.0	0.0

3.10	3.22	0.0	0.0	0.0	0.0
3.40	4.77	0.0	0.0	0.0	0.0
3.50	6.16	0.0	0.0	0.0	0.0
3.60	8.50	0.04	0.0	0.0	0.0
4.00	0.0	8.23	0.0	0.0	0.0
4.10	0.0	0.0	9.17	0.0	0.0

TABLE G-I (cont'd)

4.20	0.0	10.57	0.0	0.0	0.0
4.30	12.53	0.0	0.0	0.0	0.0
4.70	0.0	14.00	0.0	0.0	0.0
4.80	0.0	0.0	12.79	0.0	0.0
5.00	0.0	0.0	14.18	0.0	0.0
5.10	20.11	0.0	0.0	0.0	0.0

5.20	0.0	0.0	18.52	0.0	0.0
5.40	0.0	0.0	0.0	17.67	0.0
5.50	0.0	22.18	0.0	0.0	0.0
5.70	0.0	0.0	20.55	0.0	24.49
6.10	0.0	0.0	0.0	21.29	0.0
6.30	0.0	0.0	0.0	22.08	0.0

6.50	0.0	0.0	23.13	25.02	0.0
6.90	0.0	0.0	0.0	29.05	25.53
7.10	0.0	0.0	0.0	0.0	30.02
7.30	0.0	0.0	0.0	0.0	32.35
7.70	0.0	0.0	0.0	0.0	30.39
7.80	0.0	0.0	0.0	36.03	0.0

8.00	0.0	0.0	0.0	0.0	43.97
9.30	0.0	0.0	0.0	0.0	45.09

WINDOWS

	1	2
0.15	0.0	0.0
0.30	0.0	30.00
0.35	41.00	0.0
0.50	67.00	71.00
0.65	0.0	97.00

EXTERIOR DOORS

	1
0.40	0.0
0.95	83.50
1.50	144.94

ABOVE GRADE FOUNDATI

	1	2
0.20	0.0	0.0
1.10	14.16	0.0
1.30	15.52	0.0
1.50	17.06	0.0
1.70	0.0	14.50
2.00	19.74	0.0
2.10	0.0	15.12
2.40	0.0	15.65
2.80	25.12	0.0
3.10	0.0	16.76
3.80	0.0	17.74
4.20	0.0	18.65
4.50	0.0	19.16
4.90	0.0	19.75
5.20	0.0	19.80

TABLE G-I (cont'd)

BELOW GRADE FOUNDATI

	1	2
0.20	0.0	0.0
1.10	14.16	0.0
1.30	15.52	0.0
1.50	17.06	0.0
1.70	0.0	14.50
2.00	19.74	0.0
2.10	0.0	15.12
2.40	0.0	15.65
2.80	25.12	0.0
3.10	0.0	16.76
3.80	0.0	17.74
4.20	0.0	18.65
4.50	0.0	19.16
4.90	0.0	19.75
5.20	0.0	19.80

BASEMENT SLABS

	1
0.20	0.0
1.10	6.06
1.30	7.99
1.50	9.53
2.00	12.20
2.20	15.37
2.40	16.91
2.80	17.56

COMPONENT	R LEVEL	COST EFF	RUNNING TOTAL COST
ABOVE GRADE FOUNDATI	2.10	0.1807	10.29
CEILINGS	2.60	0.1335	31.89
EXTERIOR WALLS	2.70	0.1239	86.34
CEILINGS	2.30	0.1145	107.94
ABOVE GRADE FOUNDATI	2.40	0.1123	116.73
CEILINGS	3.00	0.0992	138.33
ABOVE GRADE FOUNDATI	3.10	0.0848	150.76
CEILINGS	3.20	0.0833	179.20
CEILINGS	3.40	0.0799	199.96
CEILINGS	3.50	0.0681	221.50
CEILINGS	3.60	0.0609	243.13
ABOVE GRADE FOUNDATI	3.50	0.0500	257.43
CEILINGS	4.00	0.0548	281.03
CEILINGS	4.20	0.0518	301.73
CEILINGS	4.40	0.0471	322.43
CEILINGS	4.50	0.0430	343.13
CEILINGS	4.60	0.0394	363.83
BELOW GRADE FOUNDATI	5.10	0.0383	1332.55
CEILINGS	5.00	0.0362	1653.25
ABOVE GRADE FOUNDATI	5.20	0.0344	1687.45
BELOW GRADE FOUNDATI	3.60	0.0336	1761.64
CEILINGS	5.20	0.0334	1782.34
WINDOWS	0.50	0.0330	2010.34
CEILINGS	5.40	0.0319	2037.04
CEILINGS	5.50	0.0266	2057.74
CEILINGS	5.50	0.0266	2078.44
CEILINGS	6.00	0.0250	2099.14
CEILINGS	6.20	0.0234	2119.64
EXTERIOR WALLS	3.10	0.0231	2330.57
CEILINGS	6.40	0.0219	2357.27
BELOW GRADE FOUNDATI	5.20	0.0207	2513.21
CEILINGS	6.60	0.0206	2533.91
CEILINGS	6.30	0.0194	2554.61
EXTERIOR WALLS	3.40	0.0184	2710.90
CEILINGS	7.00	0.0163	2737.60
EXTERIOR DOORS	0.95	0.0173	3038.20
CEILINGS	7.20	0.0173	3058.90
CEILINGS	7.40	0.0163	3079.60
CEILINGS	7.50	0.0155	3100.30
WINDOWS	0.65	0.0154	3370.30
EXTERIOR WALLS	3.30	0.0150	3587.03
CEILINGS	7.50	0.0147	3597.73
EXTERIOR WALLS	4.00	0.0095	3753.20
EXTERIOR WALLS	4.30	0.0091	4230.69
BASEMENT SLABS	1.10	0.0073	4330.09
EXTERIOR DOORS	1.50	0.0063	5051.27
EXTERIOR WALLS	5.00	0.0060	5190.80
BASEMENT SLABS	1.30	0.0053	5310.50
EXTERIOR WALLS	6.10	0.0051	6060.91
BASEMENT SLABS	2.00	0.0045	6439.61
CEILINGS	10.50	0.0044	7140.01
EXTERIOR WALLS	6.30	0.0037	7285.54
BASEMENT SLABS	2.60	0.0027	7707.94
EXTERIOR WALLS	7.10	0.0024	8536.44
EXTERIOR WALLS	9.30	0.0022	10114.26

TABLE G-2

RANKING OF THERMAL
IMPROVEMENTS

APPENDIX H

TABLE H-1

THERMAL CHARACTERISTICS AND COST PREMIUM

Thermal Performance Level: CEA SUPER EE

Location: Vancouver

HOUSE TYPE	SIZE*	AIR CHANGE RATE	THERMAL CHARACTERISTIC (m ² -°C/Watt)							COST PREMIUM
			Walls	Ceilling	Window	Door	Basement Walls**		Basement Floor **	
							Below Grade	Above Grade		
Bungalow	90	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80	10599***
Split Level	90	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80	10425
2 Storey	90	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80	10455
Bungalow	90	0.2	3.80	7.60	0.65	0.95	5.20	5.20	0.20	5906
Split Level	90	0.2	3.80	7.80	0.65	0.95	5.20	5.20	0.20	5254
2 Storey	90	0.2	3.80	7.80	0.65	0.95	5.20	5.20	0.20	5420
Bungalow	150	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80	14772***
Split Level	150	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80	13730***
2 Storey	150	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80	14055***
Bungalow	150	0.2	4.80	7.80	0.65	1.50	5.20	5.20	0.20	8788
Split Level	150	0.2	4.80	7.80	0.65	1.50	5.20	5.20	0.20	7929
2 Storey	150	0.2	4.80	7.80	0.65	1.50	5.20	5.20	0.20	8339

* Nominal floor area (m^2).

** Resistance level includes RSI 0.2 for concrete structure.

***Does not meet energy target.

TABLE H-2

THERMAL CHARACTERISTICS AND COST PREMIUM

Thermal Performance Level: SEE CRITERIA

Location: Vancouver

HOUSE TYPE	SIZE*	AIR CHANGE RATE	THERMAL CHARACTERISTIC (m ² -°C/Watt)							COST PREMIUM
			Walls	Ceiling	Window	Door	Basement Walls **		Basement Floor **	
							Below Grade	Above Grade		
										\$
Bungalow	90	0.5	3.40	7.20	0.50	0.95	5.20	5.20	0.20	3550
Split Level	90	0.5	3.80	7.60	0.65	0.95	5.20	5.20	0.20	3320
2 Storey	90	0.5	3.80	7.60	0.65	0.95	5.20	5.20	0.20	3560
Bungalow	90	0.2	2.70	4.80	0.35	0.40	3.80	3.80	0.20	4034
Split Level	90	0.2	2.70	5.40	0.50	0.40	3.80	3.80	0.20	3626
2 Storey	90	0.2	2.70	5.40	0.50	0.40	3.80	3.80	0.20	3776
Bungalow	150	0.5	4.80	7.80	0.65	1.50	5.20	5.20	0.20	6708
Split Level	150	0.5	4.80	7.80	0.65	0.95	5.20	5.20	0.20	5563
2 Storey	150	0.5	4.80	7.80	0.65	1.50	5.20	5.20	0.20	6224
Bungalow	150	0.2	2.70	4.80	0.35	0.40	3.80	3.80	0.20	5138
Split Level	150	0.2	2.70	5.40	0.50	0.40	3.80	3.80	0.20	4577
2 Storey	150	0.2	2.70	5.40	0.50	0.40	3.80	3.80	0.20	4858

* Nominal floor area (m^2)

** Resistance level includes RSI 0.2 for concrete structure.

TABLE H-3

THERMAL CHARACTERISTICS AND COST PREMIUM

Thermal Performance Level: CEA SUPER EE

Location: Saskatoon

HOUSE TYPE	SIZE*	AIR CHANGE RATE	THERMAL CHARACTERISTIC ($m^2 \cdot ^\circ C / Watt$)							COST PREMIUM \$
			Walls	Ceiling	Window	Door	Basement Walls **		Basement Floor **	
							Below Grade	Above Grade		
Bungalow	90	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80	10025***
Split Level	90	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80	9861***
2 Storey	90	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80	9901***
Bungalow	90	0.2	7.10	10.60	0.65	1.50	5.20	5.20	2.80	10324
Split Level	90	0.2	9.30	10.60	0.65	1.50	5.20	5.20	2.80	11826
2 Storey	90	0.2	9.30	10.60	0.65	1.50	5.20	5.20	2.80	11796
Bungalow	150	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80	13867***
Split Level	150	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80	12912***
2 Storey	150	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80	13247***
Bungalow	150	0.2	9.30	10.60	0.65	1.50	5.20	5.20	2.80	16002
Split Level	150	0.2	9.30	10.60	0.65	1.50	5.20	5.20	2.80	15012
2 Storey	150	0.2	9.30	10.60	0.65	1.50	5.20	5.20	2.80	15317

* Nominal floor area (m^2).

** Resistance level includes RSI 0.2 for concrete structure.

***Did not meet energy target.

TABLE H-4

THERMAL CHARACTERISTICS AND COST PREMIUM

Thermal Performance Level: SEE CRITERIA

Location: Saskatoon

HOUSE TYPE	SIZE*	AIR CHANGE RATE	THERMAL CHARACTERISTIC (m ² -°C/Watt)							COST PREMIUM
			Walls	Ceiling	Window	Door	Basement Walls **		Basement Floor **	
							Below Grade	Above Grade		\$
Bungalow	90	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80	10025***
Split Level	90	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80	9861***
2 Storey	90	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80	9901***
Bungalow	90	0.2	4.80	7.80	0.65	1.50	5.20	5.20	1.10	6844
Split Level	90	0.2	5.00	7.80	0.65	1.50	5.20	5.20	1.10	6383
2 Storey	90	0.2	5.00	7.80	0.65	1.50	5.20	5.20	1.30	6554
Bungalow	150	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80	13867***
Split Level	150	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80	12912***
2 Storey	150	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80	13247***
Bungalow	150	0.2	4.80	7.80	0.65	1.50	5.20	5.20	1.10	8942
Split Level	150	0.2	5.00	7.80	0.65	1.50	5.20	5.20	1.10	7938
2 Storey	150	0.2	5.00	7.80	0.65	1.50	5.20	5.20	1.30	8344

* Nominal floor area (m²).

** Resistance level includes RSI 0.2 for concrete structure.

***Did not meet energy target.

TABLE H-5

THERMAL CHARACTERISTICS AND COST PREMIUM

Thermal Performance Level: CEA SUPER EE

Location: Toronto

HOUSE TYPE	SIZE*	AIR CHANGE RATE	THERMAL CHARACTERISTICS ($\text{m}^2\text{-}^\circ\text{C/Watt}$)							COST PREMIUM \$
			Walls	Ceiling	Window	Door	Below Grade	Basement Walls ** Above Grade	Basement Floor **	
Bungalow	90	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80	10188***
Split Level	90	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80	10030***
2 Storey	90	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80	10068***
Bungalow	90	0.2	6.10	10.60	0.65	1.50	5.20	5.20	0.20	7948
Split Level	90	0.2	6.10	10.60	0.65	1.50	5.20	5.20	0.20	7568
2 Storey	90	0.2	6.10	10.60	0.65	1.50	5.20	5.20	0.20	7690
Bungalow	150	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80	14088***
Split Level	150	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80	13076***
2 Storey	150	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80	13410***
Bungalow	150	0.2	6.30	10.60	0.65	1.50	5.20	5.20	1.10	11575
Split Level	150	0.2	6.10	10.60	0.65	1.50	5.20	5.20	1.10	10099
2 Storey	150	0.2	6.30	10.60	0.65	1.50	5.20	5.20	1.10	10592

* Nominal floor area (m^2).

** Resistance level includes RSI 0.2 for concrete structure.

***Did not meet energy target.

TABLE H-6

THERMAL CHARACTERISTICS AND COST PREMIUM

Thermal Performance Level: SEE CRITERIA

Location: Toronto

HOUSE TYPE	SIZE*	AIR CHANGE RATE	THERMAL CHARACTERISTICS ($m^2 \cdot ^\circ C / Watt$)							COST PREMIUM \$
			Walls	Ceiling	Window	Door	Basement Walls **		Basement Floor **	
							Below Grade	Above Grade		
Bungalow	90	0.5	6.30	10.60	0.65	1.50	5.20	5.20	1.10	6862
Split Level	90	0.5	6.10	10.60	0.65	1.50	5.20	5.20	1.10	6043
2 Storey	90	0.5	6.30	10.60	0.65	1.50	5.20	5.20	1.10	6340
Bungalow	90	0.2	3.10	6.40	0.50	0.40	3.80	3.80	0.20	4239
Split Level	90	0.2	3.40	7.20	0.50	0.95	5.20	5.20	0.20	4262
2 Storey	90	0.2	3.40	7.20	0.50	0.95	5.20	5.20	0.20	4438
Bungalow	150	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80	14088
Split Level	150	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.00	12570
2 Storey	150	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80	13410
Bungalow	150	0.2	3.10	6.40	0.50	0.40	3.80	3.80	0.20	5392
Split Level	150	0.2	3.40	7.00	0.50	0.95	5.20	5.20	0.20	5147
2 Storey	150	0.2	3.40	7.20	0.50	0.95	5.20	5.20	0.20	5506

* Nominal floor area (m^2).

** Resistance level includes RSI 0.2 for concrete structure.

TABLE H-7

THERMAL CHARACTERISTICS AND COST PREMIUM

Thermal Performance Level: CEA SUPER EE

Location: Fredericton

HOUSE TYPE	SIZE*	AIR CHANGE RATE	THERMAL CHARACTERISTIC ($m^2 \cdot ^\circ C / Watt$)							COST PREMIUM
			Walls	Ceiling	Window	Door	Basement Walls **		Basement Floor **	
							Below Grade	Above Grade		\$
Bungalow	90	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80	10185***
Split Level	90	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80	10027***
2 Storey	90	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80	10065***
Bungalow	90	0.2	6.10	10.60	0.65	1.50	5.20	5.20	2.00	9043
Split Level	90	0.2	6.10	10.60	0.65	1.50	5.20	5.20	2.00	8290
2 Storey	90	0.2	6.10	10.60	0.65	1.50	5.20	5.20	2.00	8236
Bungalow	150	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80	14129***
Split Level	150	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80	13117***
2 Storey	150	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80	13451***
Bungalow	150	0.2	7.10	10.60	0.65	1.50	5.20	5.20	2.80	14220
Split Level	150	0.2	7.10	10.60	0.65	1.50	5.20	5.20	2.80	12625
2 Storey	150	0.2	9.30	10.60	0.65	1.50	5.20	5.20	2.80	15521

* Nominal floor area (m^2).

** Resistance level includes RSI 0.2 for concrete structure.

***Did not meet energy target.

TABLE H-8

THERMAL CHARACTERISTICS AND COST PREMIUM

Thermal Performance Level: SEE CRITERIA Location: Fredericton

HOUSE TYPE	SIZE*	AIR CHANGE RATE	THERMAL CHARACTERISTIC ($m^2 \cdot ^\circ C / Watt$)						COST PREMIUM \$
			Walls	Ceiling	Window	Door	Basement Walls **		Basement Floor **
							Below Grade	Above Grade	
Bungalow	90	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80
Split Level	90	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80
2 Storey	90	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80
Bungalow	90	0.2	3.40	7.20	0.50	0.95	5.20	5.20	0.20
Split Level	90	0.2	3.80	7.80	0.65	0.95	5.20	5.20	0.20
2 Storey	90	0.2	3.80	7.80	0.65	0.95	5.20	5.20	0.20
Bungalow	150	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80
Split Level	150	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80
2 Storey	150	0.5	9.30	10.60	0.65	1.50	5.20	5.20	2.80
Bungalow	150	0.2	3.40	7.20	0.50	0.95	5.20	5.20	0.20
Split Level	150	0.2	3.80	7.80	0.65	0.95	5.20	5.20	0.20
2 Storey	150	0.2	3.80	7.80	0.65	0.95	5.20	5.20	0.20

* Nominal floor area (m^2).

** Resistance level includes RSI 0.2 for concrete structure.

***Did not meet energy target.

APPENDIX I



TABLE I-1

SUMMARY OF SPACE HEATING ENERGY REQUIREMENTS

Location: Vancouver

HOUSE TYPE	SIZE*	AIR CHANGE RATE**	NET ENERGY REQUIREMENTS (GJ)		
			1975 STANDARDS	CEA STANDARDS	SEE CRITERIA
Bungalow	90	0.5	68.4	13.4*** (11.5)	22.3
Split Level	90	0.5	56.4	8.0	15.0
2 Storey	90	0.5	56.0	7.9	14.6
Bungalow	90	0.2	56.4	10.8	20.3
Split Level	90	0.2	47.6	8.4	15.3
2 Storey	90	0.2	47.8	8.2	15.2
Bungalow	150	0.5	112.8	29.1*** (19.6)	36.7
Split Level	150	0.5	88.9	17.8*** (13.8)	25.2
2 Storey	150	0.5	91.3	18.8*** (14.1)	25.7
Bungalow	150	0.2	92.2	19.5	36.4
Split Level	150	0.2	74.6	13.2	25.6
2 Storey	150	0.2	76.5	13.6	26.4

* Nominal floor area (m²)

** Air changes per hour

*** Did not meet energy target (energy target)

TABLE I-2
SUMMARY OF SPACE HEATING ENERGY REQUIREMENTS

Location: Saskatoon

HOUSE TYPE	SIZE*	AIR CHANGE RATE**	NET ENERGY REQUIREMENTS (GJ)		
			1975 STANDARDS	CEA STANDARDS	SEE CRITERIA
Bungalow	90	0.5	103.4	38.0*** (21.1)	38.0*** (28.4)
Split Level	90	0.5	80.1	26.4*** (15.6)	26.4*** (21.0)
2 Storey	90	0.5	81.5	26.0*** (14.9)	26.0*** (20.1)
Bungalow	90	0.2	82.5	21.1	27.4
Split Level	90	0.2	65.0	13.7	21.2
2 Storey	90	0.2	66.8	13.6	20.8
Bungalow	150	0.5	162.6	69.3*** (36.2)	69.3*** (48.6)
Split Level	150	0.5	120.4	46.9*** (25.5)	46.9*** (34.3)
2 Storey	150	0.5	126.1	48.9*** (26.0)	48.9*** (34.9)
Bungalow	150	0.2	126.6	35.9	48.0
Split Level	150	0.2	95.2	24.6	35.1
2 Storey	150	0.2	99.9	25.7	35.9

* Nominal floor area (m²)

** Air changes per hour

*** Did not meet energy target (energy target)

TABLE I-3

SUMMARY OF SPACE HEATING ENERGY REQUIREMENTS

Location: Toronto

HOUSE TYPE	SIZE*	AIR CHANGE RATE**	NET ENERGY REQUIREMENTS (GJ)		
			1975 STANDARDS	CEA STANDARDS	SEE CRITERIA
Bungalow	90	0.5	74.5	21.9*** (13.9)	24.3
Split Level	90	0.5	58.4	14.5*** (10.3)	17.4
2 Storey	90	0.5	59.5	14.4*** (9.8)	17.0
Bungalow	90	0.2	60.0	13.3	25.0
Split Level	90	0.2	47.8	9.6	17.3
2 Storey	90	0.2	49.2	9.6	17.2
Bungalow	150	0.5	117.9	41.7*** (23.8)	41.7
Split Level	150	0.5	87.8	27.4*** (16.8)	27.6
2 Storey	150	0.5	92.1	28.9*** (17.1)	28.9
Bungalow	150	0.2	92.7	23.5	41.1
Split Level	150	0.2	70.4	16.7	28.4
2 Storey	150	0.2	74.1	17.4	29.4

* Nominal floor area (m²)

** Air changes per hour

*** Did not meet energy target (energy target)

TABLE I-4

SUMMARY OF SPACE HEATING ENERGY REQUIREMENTS

Location: Fredericton

HOUSE TYPE	SIZE*	AIR CHANGE RATE**	NET ENERGY REQUIREMENTS (GJ)		
			1975 STANDARDS	CEA STANDARDS	SEE CRITERIA
Bungalow	90	0.5	84.0	27.4*** (15.9)	27.4
Split Level	90	0.5	65.9	18.4*** (11.7)	18.4
2 Storey	90	0.5	66.6	18.0*** (11.2)	18.0
Bungalow	90	0.2	67.0	15.4	26.2
Split Level	90	0.2	53.4	11.4	19.0
2 Storey	90	0.2	54.5	11.4	18.6
Bungalow	150	0.5	133.8	52.2*** (27.2)	52.2*** (44.7)
Split Level	150	0.5	99.9	34.5*** (19.2)	34.5*** (31.5)
2 Storey	150	0.5	104.0	36.1*** (19.5)	36.1*** (32.1)
Bungalow	150	0.2	104.6	27.5	45.7
Split Level	150	0.2	79.5	19.0	31.3
2 Storey	150	0.2	82.8	17.8	32.1

* Nominal floor area (m²)

** Air changes per hour

*** Did not meet energy target (energy target)

APPENDIX J



TABLE J-1

SUMMARY OF HEAT LOSS FACTORS

Location: Vancouver

HOUSE TYPE	SIZE*	AIR CHANGE RATE**	APPROXIMATE HEAT LOSS FACTOR (W/°C)		
			1975 STANDARDS	CEA STANDARDS	SEE CRITERIA
Bungalow	90	0.5	327.0	120.0***	157.0
Split Level	90	0.5	278.0	95.0	126.0
2 Storey	90	0.5	282.0	95.0	124.0
Bungalow	90	0.2	290.0	111.0	151.0
Split Level	90	0.2	250.0	98.0	128.0
2 Storey	90	0.2	254.0	97.0	128.0
Bungalow	150	0.5	493.0	191.0***	222.0
Split Level	150	0.5	403.0	145.0***	175.0
2 Storey	150	0.5	415.0	150.0***	178.0
Bungalow	150	0.2	428.0	158.0	223.0
Split Level	150	0.2	357.0	128.0	178.0
2 Storey	150	0.2	368.0	130.0	182.0

* Nominal floor area (m²)

** Air changes per hour

*** Did not meet energy target

TABLE J-2

SUMMARY OF HEAT LOSS FACTORS

Location: Saskatoon

HOUSE TYPE	SIZE*	AIR CHANGE RATE**	APPROXIMATE HEAT LOSS FACTOR (W/°C)		
			1975 STANDARDS	CEA STANDARDS	SEE CRITERIA
Bungalow	90	0.5	256.0	121.0***	121.0***
Split Level	90	0.5	205.0	96.0***	96.0***
2 Storey	90	0.5	211.0	96.0***	96.0***
Bungalow	90	0.2	219.0	87.0	101.0
Split Level	90	0.2	177.0	68.0	86.0
2 Storey	90	0.2	183.0	68.0	85.0
Bungalow	150	0.5	383.0	193.0***	193.0***
Split Level	150	0.5	294.0	147.0***	147.0***
2 Storey	150	0.5	308.0	151.0***	151.0***
Bungalow	150	0.2	318.0	128.0	153.0
Split Level	150	0.2	248.0	101.0	124.0
2 Storey	150	0.2	261.0	104.0	126.0

* Nominal floor area (m²)

** Air changes per hour

*** Did not meet energy target

TABLE J-3

SUMMARY OF HEAT LOSS FACTORS

Location: Toronto

HOUSE TYPE	SIZE*	AIR CHANGE RATE**	APPROXIMATE HEAT LOSS FACTOR (W/°C)		
			1975 STANDARDS	CEA STANDARDS	SEE CRITERIA
Bungalow	90	0.5	269.0	119.0***	126.0
Split Level	90	0.5	220.0	95.0***	104.0
2 Storey	90	0.5	225.0	95.0***	103.0
Bungalow	90	0.2	231.0	92.0	130.0
Split Level	90	0.2	192.0	78.0	105.0
2 Storey	90	0.2	198.0	78.0	105.0
Bungalow	150	0.5	400.0	189.0***	189.0
Split Level	150	0.5	312.0	144.0***	145.0
2 Storey	150	0.5	327.0	149.0***	149.0
Bungalow	150	0.2	335.0	135.0	191.0
Split Level	150	0.2	266.0	110.0	149.0
2 Storey	150	0.2	280.0	113.0	152.0

* Nominal floor area (m²)

** Air changes per hour

*** Did not meet energy target

TABLE J-4

SUMMARY OF HEAT LOSS FACTORS

Location: Fredericton

HOUSE TYPE	SIZE*	AIR CHANGE RATE**	APPROXIMATE HEAT LOSS FACTOR (W/°C)		
			1975 STANDARDS	CEA STANDARDS	SEE CRITERIA
Bungalow	90	0.5	263.0	120.0***	120.0
Split Level	90	0.5	214.0	95.0***	95.0
2 Storey	90	0.5	218.0	95.0***	95.0
Bungalow	90	0.2	226.0	89.0	120.0
Split Level	90	0.2	186.0	76.0	98.0
2 Storey	90	0.2	191.0	77.0	97.0
Bungalow	150	0.5	394.0	191.0***	191.0***
Split Level	150	0.5	306.0	146.0***	146.0***
2 Storey	150	0.5	319.0	150.0***	150.0***
Bungalow	150	0.2	329.0	131.0	180.0
Split Level	150	0.2	260.0	106.0	140.0
2 Storey	150	0.2	271.0	103.0	142.0

* Nominal floor area (m²)

** Air changes per hour

*** Did not meet energy target

APPENDIX K

TABLE K-1

SUMMARY OF IMPROVEMENTS TO SLAB ON GRADE BUNGALOW

THERMAL CHARACTERISTICS AND COST PREMIUM

Location: Vancouver

House Type: 150 m² nominal floor area, BUNGALOW SLAB ON GRADE

THERMAL PERFORMANCE LEVEL	AIR CHANGE RATE	THERMAL CHARACTERISTIC (m ² -°C/Watt)					COST PREMIUM
		Walls	Ceiling	Window	Door	Floor Slab on Grade	
1975 Standards	0.5	1.63	1.63	0.15	0.40	0.20	0.0
	0.2						
CEA Double-E	0.5	9.30	10.60	0.65	1.50	2.80	12064 *
	0.2	6.90	7.80	0.65	1.50	2.80	10806
SEE Criteria	0.5	4.80	7.80	0.65	1.50	2.80	7147
	0.2	3.40	7.80	0.65	0.95	0.20	5184

* Did not meet energy target.

TABLE K-2

SUMMARY OF IMPROVEMENTS TO SLAB ON GRADE BUNGALOWSUMMARY OF APPROXIMATE HEAT LOSS FACTOR AND SPACE HEATING ENERGY REQUIREMENTS

Location: Vancouver

HOUSE TYPE	SIZE*	AIR CHANGE RATE**	NET ENERGY REQUIREMENTS (GJ)			HEAT LOSS FACTOR (W/°C)		
			1975 STANDARDS	CEA STANDARDS	SEE CRITERIA	1975 STANDARDS	CEA STANDARDS	SEE CRITERIA
Bungalow Slab on Grade	150	0.5	80.7	14.5*** (9.8)	18.6	380.0	136.0***	153.0
	150	0.2	70.7	10.0	18.5	350.0	115.0	158.0

* Nominal floor area.

** Air changes per hour.

*** Did not meet energy target (energy target).

